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Bees and Fruit

From a photograph of a cluster of "Wealthy" apples grown in a bee-pollinated orchard at Kendaia, New York.

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THE BEEKEEPER and the FRUIT - GROWER

WHY AND HOW THEIR INTERESTS are MUTUAL

HOW THE FRUIT-GROWER CAN KEEP A FEW BEES TO POLLINATE HIS FRUIT TREES WITH THE LEAST POSSIBLE TROUBLE

By E. R. ROOT

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PREFACE.

Much of the matter in this booklet was prepared at the special request of the Secretary of the Ohio Agricultural Society and was read before that body at one of its meetings at Columbus, Ohio.

In this paper I attempted to show the invaluable service performed by the bees in fertilizing fruit blossoms; also the difference in fruitage between the limbs of trees covered with netting to keep off bees and those not so covered.

As I appeared as a beekeeper and for the bees, I thought, perhaps, that there might be some objections raised by the fruit-growers to some of my statements on the subject. I was agreeably surprised to find how nearly they assented to my every claim. They not only endorsed what I said, but introduced additional evidence to show the close interrelation between the two interests. They also assented to the proposition that no good could come from spraying trees while in bloom; but, in some cases at least, positive damage was done to the embryo fruit itself.

The facts herein presented ought to set at rest at once and forever the charge of a few fruit-growers, that bees are a nuisance and a damage to their interests.

Many fruit-growers would keep a few bees to pollinate their fruit trees if they could do so with little trouble. I show how this can be done and at the same time be a source of profit in production of honey.

This pamphlet is issued with the hope that it may be the means of helping the fruit-grower, as well as the beekeepers, to see how vitally related are their interests, for where much fruit is grown, there bees thrive; and, vice versa, the largest percentage of fruit matures where there are plenty of bees.

Medina, Ohio, Oct. 1, 1919. E. R. Root.

WHY FRUIT NEEDS BEES.

Do bees perform a valuable service to the fruit-grower in cross-pollinating fruit trees?

I am safe in saying that it will be generally admitted that they do perform a great service. On this point an immense amount of data has been offered by scientific and practical men. I will here present for your consideration only some of the authoritative evidence on the subject, not only by beekeepers but by fruit-growers and experiment stations alike.

One colony of honeybees should be provided for each acre of orchard.

This was the conclusion of Prof. W. P. Tufts of the College of Agriculture, University of California, as stated in 1919, Bulletins Nos. 306 and 307, on the pollination of both the Bartlett pear and the almond. This is the very highest authority in the case of the pear and the almond.

Prof. A. J. Cook, Professor of Entomology, in 1891, at Michigan Agricultural College, said:

I tried many experiments last spring. I counted the blossoms on each of two branches, or plants, of apple, cherry, pear, strawberry, raspberry and clover. One of these in case of each fruit, or each experiment, was surrounded by cheese-cloth, just before the blossoms opened, and kept covered till the blossoms fell off. The apple, pear, and cherry were covered May 4th, and uncovered May 25th and May 19th. The number of blossoms considered varied from 32, the smallest number, to 399, the largest. The trees were examined June 11 to see what number of the fruit had set. The per cent of blossoms which developed on the covered trees was a little over 2, while almost 20 per cent of the uncovered blossoms had developed.

J. C. Gilligand, in the summer of 1893, in a large field of medium red clover that came within thirty feet of his door, covered some blossoms with netting. During the following August he gathered seed from the

covered blossoms, and also some from the plants not covered; and by carefully counting the seeds he found that the latter gave 21 per cent more seeds. His experiments were repeated again with like results.

J. F. McIntyre was a delegate at the California State Fruit-growers' Association for 1893, and reported:

A gentleman stated that he had a friend in this State who started into fruit-growing several years ago, locating thirty-five miles from any fruit-growing section, or where any bees were located. The first year that his trees blossomed, and in expectancy of at least some returns from his orchards, what should be the result but complete failure? He was advised to procure some bees to aid in the fertilization of the blossoms. He did so, and since then his orchard has been productive.

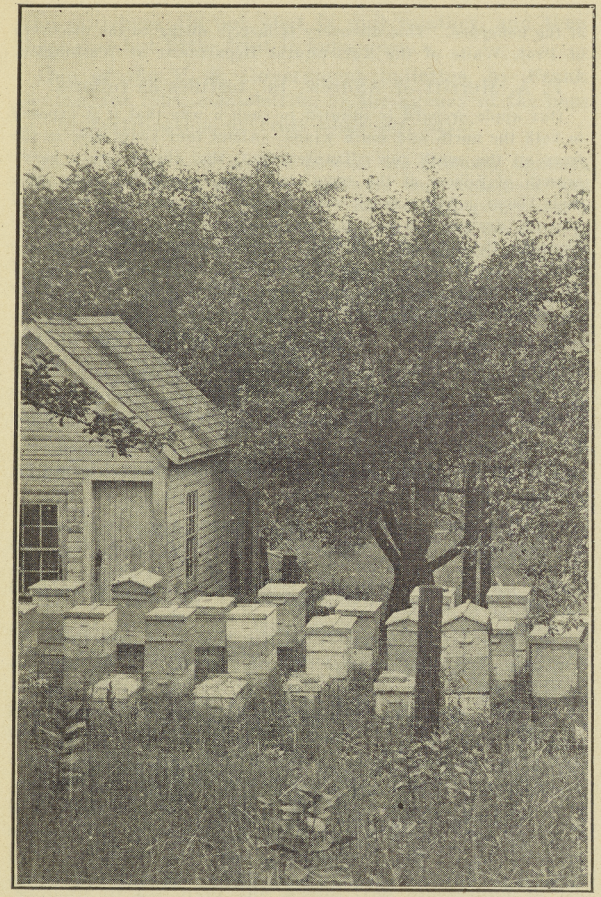
C. J. Berry, one whose fruit orchard contains 440 acres, and who was Horticultural Commissioner for Tulare County, Cal., an inland county that has made great progress in the fruit industry, gives this valuable testimony:

Bees and fruit go together. I can't raise fruit without bees. Yes, sir'ee. I have been all about my big orchard. Two years in succession I have put netting over some limbs of trees; and while they blossomed all right, nary fruit; while on the same tree, where limbs were exposed to the aid of bees, plenty of fruit.

Some years ago, in the State of Michigan, a convention of fruit-growers and beemen assembled for the purpose of discussing their common interests; and the fruit-men acknowledged generally that the keeping of bees in the vicinity of their orchards was an important factor in the production of fruit.

Again, Chas. A. Green, editor of Green's Fruit Grower, published at Rochester, N. Y., writes:

It has now become demonstrated that many kinds of fruits, if not all kinds, are greatly benefited by the bees, and that a large portion of our fruit, such as the apple, pear, and particularly the plum, would be barren were it not for the helpful work



The hives and the honey house are here located right in the orchard.

of the honeybee. This discovery is largely owing to the discovery of Prof. Waite of the Agricultural Department at Washington.

F. A. Merritt of Andrew, Ia., testifies as follows:

Our apple orchard is situated in such a way that it is exposed to both the north and south winds. About four years ago, as the trees on the south row (Transcendent, that throw out a heavy growth of foliage at the same time they bloom) began to open their bloom, a heavy south wind prevailed for about five days. I noticed, during this period, that the bees could not touch the bloom on the south side of these trees, but worked merrily on the more sheltered limbs on the north side. What was the result? Those limbs on the north side were well loaded with fruit, while on the south side there was almost none to be seen.

H. A. Marsh of Puget Sound, Wash., one of the most extensive seed-growers on the Pacific coast, testifies that he found the bees very valuable, and that the seed was very much more abundant when the bees were allowed to work on the flowers.

The editor of the Rural New-Yorker put in his paper, unsolicited, this short, pithy paragraph:

In those great greenhouses near Boston, where early cucumbers are grown, it is always necessary to have one or two hives of bees inside to fertilize the flowers. No bees, no cucumbers, unless men go around with a brush and dust the pollen from one flower to another.

A legislative committee of the House of Assembly of Ontario, 1892, gave evidence of the agency of bees in scattering pollen. The Minister of Agriculture summoned not only the leading beemen, but those engaged in growing fruit, to present the facts, experience, and the pros and cons on both sides. Not only this, but the scientists were also summoned from Ottawa and Guelph. The horticulturists, with one single exception, admitted the valuable and indispensable offices performed by the honeybees in the fertilization of fruit bloom. And this was corroborated and confirmed by the entomologist, Prof. James Fletcher, the Dominion Entomologist,

who said bees did not visit in dull weather, and then there was but little fruit in consequence.

One of the U. S. Government bulletins, by Frank Benton, for 1894, commenting on the agency of the bees in the fertilization of fruit blossoms, says:

> The facts they have brought forward are gradually becoming more widely known among fruit-growers and beekeepers, and additional evidence accumulates. A case illustrating very clearly the value of bees in an orchard has recently come to the notice of the writer. For several years the cherry crop of Vaca Valley, in Solano County, Cal., has not been good, altho it was formerly quite sure. The partial or complete failures have been attributed to north winds, chilling rains, and similar climatic conditions; but in the minds of Messrs. Bassford of Cherry Glen these causes did not sufficiently account for all the cases of failure. * * * To test the matter, they placed, therefore, several hives of bees in their orchard in 1890. The result was striking, for the Bassford orchard grew a good crop of cherries; while other orchardists in the valley who had no bees found their crops entire or partial failures.

Prof. Bailey, the very able horticulturist of Cornell University, says: "Bees are much more efficient agents of pollination than wind in our fruits, and their absence is always deleterious."

The Division of Vegetable Pathology of the Department of Agriculture, Washington, D. C., has issued a most valuable bulletin on "Pollination of Pear Flowers," by Norman B. Waite. Mr. Waite says: "Incidental mention has been made of insect visitors. We should not proceed without laying some stress upon the importance of these visits. The common honeybee is the most regular, important, and abundant visitor, and probably does more good than any other species."

Prof. V. H. Lowe of the Geneva Experiment Station, New York, in 1899, covered with a gauze hood a certain set of small pear trees. This hood was large enough to slip over the whole tree, something in the

form of a bag, and the lower end of it was tied around the trunk of the tree. The object of this was to keep out insects, ants, bees, and anything, in fact, that might assist in pollenizing the blossoms. On all of these trees so covered there was a large number of buds, and all the conditions were favorable to a good crop, except that the visit of insects was entirely cut off. Now, then, for the results: Out of the whole lot of trees covered there was just one fruit. On another set of trees of the same sort not covered there were 145. In another case, where it was not practical to envelop the whole tree, one large limb would be enclosed in the bag, the mouth of the bag being tied around the trunk of the limb. In one instance there were 2,483 buds on part of an apple tree thus covered with the sheeting. Out of that number just one fruit matured. There was plenty of fruit on other portions of the trees where the limbs were not covered. In one case where the sheeting opened so that insects could get in there were 13 perfect fruits from 818 buds. It was clearly shown that bees or other insects play an important part in the pollination of average fruit trees.

F. A. Waugh, the authority already referred to, and author of the standard text-book, the "American Apple Orchard," says that in the early spring bees are almost the only sources of pollination. The experiments he has conducted show that wind, rain, etc., have very little to do with the matter.

In California some careful experiments were conducted in testing out the value of bees as pollinators in prune orchards. In Bulletin 274, College of Agriculture, University of California, Berkeley, Cal., an account is given of how certain prune trees were covered with mosquito netting to prevent bees and other insects from getting at the trees. Another set of trees were covered with netting , and under this netting was placed a hive of bees. The test showed conclusively

that the trees visited by the bees had an abundance of fruit, while those screened from bees had but very little fruit. Since then the prune-growers are paying beekeepers from three to five dollars per colony to put bees in their orchards during the period the trees are in bloom, after which they may be removed.

Experiments were conducted by the U. S. Department of Agriculture, at Washington, D. C., in testing out the value of bees in pollination of clover blossoms. Certain patches of clover fields were covered with mosquito netting. The results showed that the covered patches yielded but very little seed; while those uncovered and visited by the bees yielded the usual amount of seed.

At a joint meeting of the National Pomological Society and the National Beekeepers' Association, held on Sept. 12, 1901, at Buffalo, a number of valuable papers were read—all of them testifying to the invaluable office of the bees in pollinating fruit blossoms. Space will permit us to give only two references. Prof. James Fletcher of the Ottawa Experiment Station, among other things, said:

> It will be found that not only are flowers absolutely necessary to bees, as the source of their food—nectar and pollen—but that bees and other insects are no less necessary to most flowers, so that their perpetuation may be secured.
>
> This fact should be recognized by the fruit-grower above all others; for were it not for insects, and particularly for the honeybee, his crops of fruits would be far less than they are every year, and even in some cases he would get no fruit at all.
>
> Failure in the fruit crop is more often due, I think, to dull or damp weather at the time of blossoming, which prevents insects from working actively in the flowers, than to any other cause.

At the same joint meeting of bee and fruit men, H. W. Collingwood, editor of the Rural New-Yorker, one of the best and most reliable agricultural papers, said:

We can easily forgive the bee its short working days when we consider the good it does. There is no question about the debt fruit-growers owe it. People talk about the wind and other insects in fertilizing our flowers; but I am confident that any man who will really take the time and pains to investigate for himself will see that the bee is nearly the whole story. I have seen the certain results of its good work in a neighbor's orchard. Those bees "broke the trees" down just as truly as tho they had climbed on the trees by the million and pulled at them. The appearance of those trees after a few years of bee-keeping would have convinced any fair-minded man that our little buzzing friends are true partners of the fruit-grower.

In addition to all this we may state that there has been a demand of late on the part of a large number of extensive fruit-growers of Wisconsin, Michigan, New York, and Pennsylvania, asking beekeepers to locate a few colonies in orchards near which there have been no bees. Indeed, the fruit-growers have offered to furnish the space and buildings necessary to accommodate the bees and appliances, free of charge to the beekeepers. It is needless to say that the latter have availed themselves of the opportunity, for honey from fruit blossoms is some of the very finest ever produced, and the fruit-grower profits immensely in his turn.

Some rather interesting cases have come under my own direct observation. About nine miles north of Medina there is a fifty-acre apple orchard. This orchard had been neglected for a number of years, when it was finally taken over by Van Rensselaer & Southham. The new proprietors immediately began the work of trimming and spraying the trees, of which they were in urgent need. Last of all, but not least important, they asked me to put some bees on the place. I placed there about one colony to the acre. The results were that the first season developed a crop of 16,000 bushels of apples. The next three or four years, with the exception of one, crops from 10,000 to 15,000 bushels were

harvested. Mr. Van Rensselaer was emphatic in saying that our bees played no small part in this result.

About ten miles east of us is a large cherry orchard. One year in particular, it was very chilly when the trees were in bloom. It was distinctly noticeable that the trees within 50 feet of the hives had large yields, while those several hundred feet away had little or no fruit. It was plain that the bees on account of the cold could fly but a short distance.

Around Cape Cod, Massachusetts, it was found that in the great cranberry bogs for some reason the growers could get only moderate yields where formerly in the small bogs they had secured large ones. While in that State one summer I received a message from the president of the Cape Cod Cranberry Co. asking me to visit the bogs. I did so. I found that where the bogs were small the wild bees in the vicinity were sufficient to pollinate the blossoms. Where the acreage of the bogs was increased from tenfold to a hundredfold the bees in the vicinity were entirely inadequate for the work. On my recommendation the company bought some bees, and reported later that their yields were greatly increased.

One of the most successful fruit-growers in the United States is C. J. Baldridge of Kendaia, N. Y.; and he is not only an extensive fruit-grower, but a beekeeper. His testimony showing the value of bees is very strong. In Gleanings in Bee Culture for May, 1917, Mr. Baldridge enumerated the three or four factors most necessary to successful fruit-growing. At the close of this enumeration, he said, "Last, but not least, there should be bees in or near the orchards, and plenty of them." It was from an apple tree in Mr. Baldridge's orchards that the branch of Wealthy apples was taken, a picture of which is shown on the front cover page of this booklet.

In one of the leading fruit journals of the country, Better Fruit, for July, 1909, appears a very strong article from the Oregon College Experiment Station, showing the almost indispensable service performed by bees in pollinating fruit trees. It is shown conclusively that many varieties are sterile to their own pollen; that wind itself is not a very important factor in carrying it from one tree to another; that the bee is practically the sole agent in doing this important work.

For an exhaustive treatment of this subject see "Fruit Blossoms, Pollen, and Pollination of Flowers," in the A B C and X Y Z of Bee Culture, published by The A. I. Root Co.

If anybody desires to secure more facts relative to flower-fertilization, he can consult "Mueller's Fertilization of Flowers," an authority on the subject.

How the Fruit-Grower May Easily Keep Bees.

Admitting then that bees do play an important part in pollinating fruit blossoms, it is apparent that the fruit-grower, if no bees are kept within half a mile of his place, ought to keep at least a few himself.

But he may object on the ground that he is afraid of their stings. This is a mistake. When properly handled, bees are quite tractable. As a general thing they will mind their own business much better than poultry or other farm stock when neglected.

But Mr. Fruitgrower will say that he can not afford to waste any time in handling swarms. He would be willing to keep a few bees—yes, would be very glad to do so if he could place a few colonies in his orchard without having the "everlasting swarming." I may say that this difficulty may be largely overcome; and for the benefit of the fruit-grower who desires to keep bees, not only for the good they may do in increasing his crops, but for the honey that they may gather, it

A 10-year-old apple tree, laden with fruit, pollinated by bees.

may be well to give here a method by which he can handle the problem satisfactorily.

Bees swarm primarily because of lack of room in the hive. If, instead of using a single hive, we use one of double capacity, one on top of the other, the swarming tendency will be very materially curtailed. We therefore advise the fruit-grower to use hives of large size, or else hives of ordinary size, one piled on top of the other. The bees and queen should be given unlimited room, and they should be run for extracted or chunk honey—not for the comb honey in the little section boxes that one sees for sale in stores. It is assumed that the fruit-grower does not care for honey in sections. For his own family chunk honey stowed away in large stone crocks will suit his purpose quite as well as that stored in the small section boxes seen in the groceries. For that reason honey should be stored in regular frames or "racks," as some call them, that hold the comb. It may be taken off and stored in the aforesaid crocks.

At the beginning of the season one story of a Langstroth hive will be enough. Just before the fruit bloom comes on, another story may be added containing empty combs or frames of comb foundation, if the colony is strong enough. As the season advances, another story should be added. In the meantime a large, unobstructed entrance should be provided at the bottom. If the bees cluster out in front they will be almost sure to swarm; so that at all times there should be enough room provided so that they can be kept inside of the hive and at work.

A single colony so manipulated may store for the fruit-grower, from fruit bloom and clover, from 50 to 200 pounds of fine honey, which will be worth, at the very lowest calculation (today, 1920) in the form of chunk honey, at the local groceries, not less than thirty cents per pound. It goes to show, then, that in a

fair season our fruit-growers, to say nothing of the actual benefit of the bees in scattering pollen, may get from $10 to $40 per hive. But if the latter figure is reached, the fruit-grower must be willing to spend a little time on bees—perhaps an hour or two to the hive for the season.

By modern methods it is not necessary that the fruit-grower himself give very much attention to the bees. He can turn that all over to his wife or children; and if he will let them have all the money they can make from the bees, he may rest assured they will soon acquire the art of handling them, and at the same time lay aside a neat sum of money.

It should be stated that there are some exceptional seasons when the bees will hardly make their own living. Indeed, they may require to be fed sugar syrup in order to keep them from starving outright; but there is only rarely so poor a season. In the good years the bees will more than make up the cost expended on them, several times over.

If the fruit-grower has not made any study of bees and cannot take the time to do so, he would do well to hire some beekeeper to look the bees over two or three times a year, say in the early spring, again just before the main honey-flow season, and again in the early fall. Such a beekeeper, besides giving the bees the immediate attention they may need, will direct the owner as to what further attention they may require and which the owner himself will be able to give them. It will be money well invested to employ an experienced beekeeper to this small extent, as the bees when put in good condition will repay the cost of their care many times over.

The keeping of a few colonies—eight or ten—will give very much larger returns per hive than the keeping of a large number. If the farmer or fruit-grower is located in the vicinity of one hundred or two hun-

dred colonies it will hardly pay him to keep any bees, as he would not stand very much of a show. But one in an isolated locality may keep from ten to twenty-five colonies to very good advantage; and, if there is no beekeeper in his vicinity, he can hardly afford not to keep them, as they will yield him far larger returns, for the time and money invested, one year after another, than will any other of his sources of profit.

BEES FALSELY CHARGED WITH INJURING FRUIT.

A few years ago there was an antagonism between the fruit-grower and the beekeeper; but I am happy to observe that this has almost entirely disappeared, because both sides recognize that Nature, apparently, has designed that the two should work in harmony; and it therefore follows to a greater or less extent that the one is dependent somewhat on the other. The statement was also made that bees could cut into ripe or sound fruit; but the facts of recent years have disproved this. In two or three cases, where the matter has been referred to the courts, the bees have been declared not guilty. The most celebrated case of the kind was that of Utter vs. Utter that took place at Amity, N. Y. The jury was unanimous to the effect that bees do not puncture sound fruit.

Bees have sometimes been accused of puncturing grapes; but careful examination shows that small birds with a sharp beak, conspicuously the Cape May warbler and the Baltimore oriole, pierce the grapes. The small, sharp, needle-like holes left in the berries are visited by the bees during the day, during which they suck out all the pulp, leaving nothing but the shriveled skins. Thus it is that the bees get the credit of doing mischief that the birds have actually made possible. For information on this subject refer to Dr. Merriam of the

With the beehives set right under the fruit trees or garden vines, and with his boy trained to do the light work of caring for the bees, the fruit-grower has struck a happy combination.

United States Department of Agriculture, Washington, D. C.

But it must not be denied that bees will visit overripe fruit that has cracked open or partially decayed fruit. They work over such fruit during a scarcity of nectar, sucking out the juices, and leaving only the mere shell of the fruit. Some fruits of this kind have a market value; and when the bees help themselves to them in a wholesale way, as they sometimes do, there is no dodging the fact that a damage has been done. In that case the owner of the bees should remove them temporarily (just before the fruit ripens) or reimburse the fruit-grower.

But a little intelligent management on the part of the beekeeper will avoid any trouble of this kind. When there is a dearth of honey the bees may be fed near the hives by giving them access to thin sugar syrup. Means must be provided so that they will not be able to get this food too rapidly. While thus kept busily engaged taking the syrup they will not touch any broken fruit. Where peaches and pears are exposed in baskets, the owner of such fruit should see to it that they are covered with mosquito netting.

The charge has been made that the bees have been the means of scattering pear blight in the regions where pears are grown largely. There have been a large number of experiments conducted to determine this matter and it is now shown conclusively that bees have little or no part in the spread of pear blight, twig or blossom blight. This blight is a bacterial disease that attacks the twigs and the ends of the branches. If not checked, it may extend to the entire branch or tree. In the spring the affected limbs exude a gummy substance filled with germs called "Holdover-cankers." It has been definitely proved that flies, ants, aphids, (or plant lice), leaf hoppers and certain other bark-piercing insects in connection with rains are the means

of carrying this blight. It has been observed that when the plant lice are abundant, fireblight is most prevalent. It is also proved that bees will not visit blighted blossoms altho they will visit freely the healthy ones on the same tree.

J. H. Merrill of the Kansas Experiment Station says: "In nurseries it is not uncommon to find whole blocks of trees practically ruined by fireblight. No one would accuse the bees of visiting the young trees which have never bloomed."

In brief: Fireblight appears both before and after pear and apple trees are in bloom, and it is well known that bees do not visit the trees except for nectar and pollen; the germs of blight must be pricked into the tender tissues of the limb and honeybees have no means of puncturing or piercing the bark; experiments show conclusively that fireblight is spread by hosts of sucking and biting insects, and not by bees.

SPRAYING AND BEES.

In years gone by complaint was made that the fruit-growers sprayed their trees while in bloom. This practice has almost entirely ceased, for experiment stations everywhere have shown that as good and better results can be secured by spraying before and after bloom. To administer the poison while the trees are in flower is a damage to the fruit-grower and to the beekeeper alike—to the first mentioned, because some of the delicate parts of the blossoms are injured, killing the embryo fruit; to the beekeeper, because the bees will be poisoned in countless thousands.

It should, perhaps, be explained to those who are not familiar with the general spraying proposition that two kinds of sprays are used by the fruit-growers—one known as lime sulphur to destroy the San Jose scale, and the other to kill the codling moth, and other insects that develop during the growth of the fruit.

Lime sulphur is mainly applied to the trees during the dormant state, before they are in leaf or bloom, and it is never harmful to bees. Indeed, it acts as a repellent. The other spray, usually arsenate-of-lead solution, or Bordeaux mixture, either of which is poisonous, should be applied after the trees are out of bloom, or just as the last petals of the flowers are falling. If sprayed into the blossom, when the bees are gathering nectar, it is liable to kill them.

One of the best authorities in the United States on fruit-growing, no less a person than F. A. Waugh, author of the "American Apple Orchard," and in no way interested in bees or beekeeping, in chapter 2 of that work, says:

> Special attention should be called to the fact that apple trees should not be sprayed while in blossom. Spraying at this time is not always totally without value, but in many cases it is not only unnecessary, but even highly dangerous to the crop. Under all circumstances it is very likely to poison the bees working on the apple blossoms. This sort of damage is far-reaching in many cases; and as the bee is one of the fruit-grower's best friends we cannot afford to murder whole swarms in this way.

Again, Prof. H. A. Gossard, Entomologist of the Ohio Experiment Station, Wooster, O., writes:

> Bees in abundance are always found in or near the most productive orchards in Ohio. Many of our best orchardists are also competent beekeepers. Large crops of fruit can not be expected unless pollenizing insects are abundant during the blossoming period. There is valid experimental proof that the bees are poisoned in large numbers by spraying with arsenicals when fruit trees are in bloom. There is also conclusive experimental proof that considerable bloom is killed if caustic poisonous sprays such as are commonly used near to blooming time are pumped on the open blossoms. I believe spraying during bloom causes greater financial loss to the orchardist than to the beekeeper, even if the swarms are destroyed. Self interest as well as a due regard for the rights of beneficent neighbors forbids that spraying of orchards be performed until after the bloom has fallen.

So far as known, every experiment station in the United States advises against spraying while the trees are in bloom.

THE DEVELOPMENT OF THE APPLE FROM THE FLOWER.—THE VALUE OF THE HONEY-BEE TO THE APPLE-GROWER.

[By Prof. O. M. Osborne, Head of Horticultural Dep't, State Normal School of Idaho. Published in "Better Fruit," and reprinted by permission.]

The development of the apple from the flower is a very complex biological process. The study of this development has been entirely limited in the past to the field of botany. It is now, however, demanding a close and careful study from all of the horticulturists through-

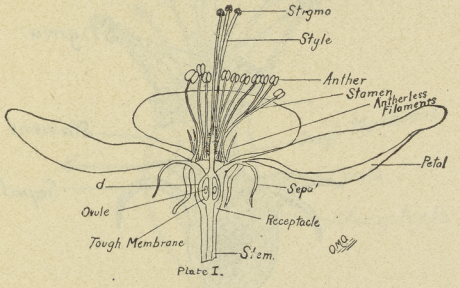


Plate I.

out the world, for it has been found that the size and shape of the fruit, the yield per acre, and the time for spraying are all dependent upon environmental conditions during blossoming time that are to a great extent under the control of man. To understand these environmental conditions, let us begin with the flower itself. In plate I is a longitudinal section of a fully opened blossom. If each part is carefully studied it will be found that every one has an important part to play in the formation and development of the fruit. Although not constituting any part of the fruit, and although dropping off within a few days, the beautiful white and

pink petals serve as an attraction for the honeybees which visit the flower to obtain the nectar from the nectar-glands. The nectar-glands are not shown in this cut, but they lie at the base of the petals on the inner side.

While climbing about the flower to reach the nectar the bee brushes against the stamens, or the male parts of the flower. From the little sac-like enlargements or anthers at the top of the stamens it receives a deposit of a powdery substance called pollen (the fecund-

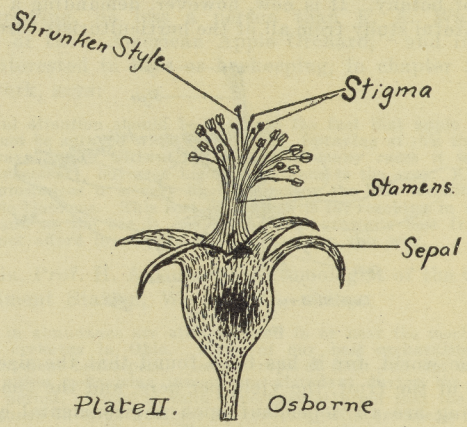
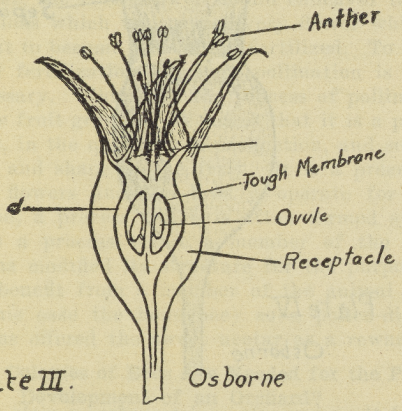


Plate II. Osborne

ating cells). You are likely familiar with the sight of a bee laden with pollen. If the little winged creature is closely examined it will be found that it carries the pollen in little collecting baskets formed of stiff hairs on the tibia of each hind leg. Under a low-power hand lens it can be seen that the pollen catches on to other parts of the bee's body. Now, when the bee rises to fly to a second flower it may brush off a little pollen on the top of the stigma of the first flower; but since

the stigma is raised above the stamens, as shown in the accompanying diagram, the chances are not as great as when the bee alights on a second flower. When it alights on the second flower it is almost certain to brush off a little pollen upon it, due to the stigma being situated above the anthers, as shown in the diagram. The pollen so deposited adheres readily on account of a sticky substance upon the stigma. Hence the flower invites through its friend, the bee, cross-pollination, and aims to prevent self-pollination by having the stigmas located far above the anthers, as before mentioned.



Apple Blossom Dependent on the Bee for Fertilization.

Without the aid of the bees but very little, if any, pollen would ever reach the stigma, for the pollen of the apple is a trifle sticky, and, unlike that of the corn tassel, ragweed, and several other familiar plants which are powdery, it cannot be distributed by the wind.

After the pollen has been deposited upon the stigma each individual grain begins to expand, due to the food and the stimulus present in the sticky sugary substance on the stigma. Soon each grain sends out a tube called a pollen tube, which penetrates the top of the stigma and grows down through the style to the ovary, where it reaches the ovules shown in the diagram. It here penetrates a very minute opening at the apex of the ovule,

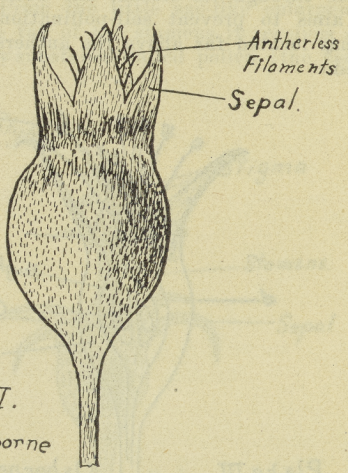


Plate IV.
Osborne

called the micropyle, and transfers a male nucleus into the egg cell within the ovule. The male sexual nucleus there unites with the female nucleus of the egg cell and completes the process of fertilization. From this union develops a cell containing protoplasm, the nitrogenous living substance of which the most rapidly growing parts of plants are mainly composed. Each little ovule in which this pollination took place gradually de-

velops into an apple seed. The different stages of this seed development are shown in the series of plates Nos. I, III, V, VI.

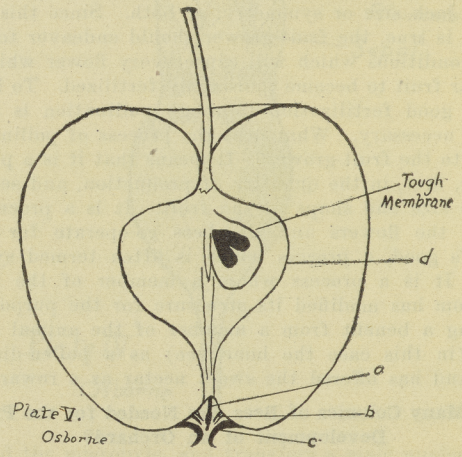
How the Flowers and the Bees Co-operate for Each Other's Good.

By experimentation extending through a number of years it has been found that if many of the ovules in the apple flower fail to become fertilized (which, of course, results in undeveloped seeds) the apple will either lack size or symmetry, or both. Since this condition is true, the fruit-grower should endeavor to furnish conditions which will cause every flower which is to bear fruit to become thoroughly fertilized. To bring about good fertilization thorough pollination is absolutely necessary. What does the process of pollination mean to the fruit-grower? It means that it is a potent factor, first, in the quantity of production, and second, in the size and shape of the fruit. It is a process in which the flowers and the bees co-operate for each other's good, a process which is often termed symbiosis. It is a process where a member of the plant kingdom has modified its structure for the purpose of reaping a benefit from a member of the animal kingdom (in this case the honeybee) as a pollen-distributor and has offered the sweet nectar as a reward.

How Many Colonies of Bees Are Needed for the Proper Development of an Orchard?

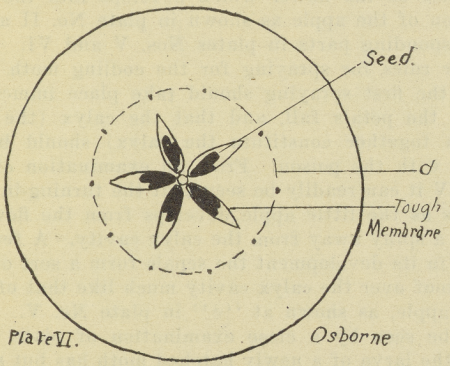
Since the pollination of the apple flowers is performed almost solely by the honeybee it behooves the fruit-grower to have bees in abundance in his orchard. It can be determined only experimentally whether or not the number of bees existing in an orchard is sufficient. The experiment may be performed by the fruit-grower by placing a hive of bees at one end or in one corner of a large orchard and then observing the

amount and shape of the fruit set. This method of determining whether bees are in sufficient abundance is, of course, expensive, for any lack of them results in a shortening of the fruit crop. Hence it is well to insure against the possibility of loss by keeping a few hives of bees distributed through the orchard. Bees not only will often increase the quality and quantity of the fruit, but incidentally will furnish the fruit-grower with wax for grafting, and with honey for the home.



While bees are necessary in every orchard to carry on the work of pollination, successful pollination can occur only where the different varieties are set out with reference to the time of blossoming. Only certain varieties of apples will pollenize well together. It is, therefore, obvious that their time of blossoming must be the same. In order to produce fruit, not only should the time of blossoming be the same, but the flowers of

any one variety must be capable of either being fertilized by their own pollen or by the pollen of some closely related variety. We thus have those that are termed self-fertile (fertile to their own pollen) and those that are termed self-sterile (sterile to their own pollen). There are also varieties which are only partially self-sterile. Due, perhaps, to environmental conditions, the class to which any one variety of apples belongs varies in different localities. Not only do the environmental conditions represented by climate and soil determine the class to which any variety of apples



belongs, but they even determine the quantity of pollen produced. Hence it becomes of especial scientific interest to us when we consider that these environmental factors influence the characteristics and behavior of the germ-cell of the plant. By writing to your State experiment station you can usually obtain a list of the apples which pollinate well together, and of those that blossom at the same time. Such a list becomes very valuable for reference at the time of planting an orchard.

Let us consider the changes in the fertilized flower after the petals have fallen and their relation to orchard spraying. By examining plates Nos. II and III it will be seen that the changes that are evident in the remainder of the flower are shown in the way of a shrunken style and stigma, in the open and empty anther sacs which contained the pollen and in the somewhat larger receptacle. Now let us examine plate No. IV. In this we find that the sepals are turning inward, due to the enlargement of that part of the original flower in plate No. 1, termed the receptacle. It is the receptacle of the flower which develops into the edible portion of the apple as shown in plate No. II and the corresponding parts in plates Nos. V and VI.

Our rules for spraying for the codling moth tell us that the first spraying should take place immediately after the petals fall, and that the calyx (the sepals taken together constitute the calyx) should be well filled with the poison. From an examination of plate No. IV it can readily be seen that the turning-in of the sepals as the little apple develops from the flower directs a spray away from the calyx cavity. A few days later in its development the sepals form a sort of cone-like roof over the calyx cavity much like that of a mature apple, as shown at "c" in plate No. V. It can also be seen by a close examination of plate No. II that the larva of a newly hatched moth has but a small distance to eat to reach the center of the little apple during the early stages of its growth. It is also noticeable that the calyx cavity during the early stages is quite pointed; hence, if the poison is well placed during spraying, the larva is sure to eat it in its endeavor to reach the inside of the apple. Thus we find that each part of the flower after unfolding from the bud gradually passes through natural changes in developing into the apple. These changes not only have a highly complex and interesting biological significance from the

standpoint of the lovers of nature, but also have a practical relationship to the management of the orchard and to the quantity and quality of the fruit produced.

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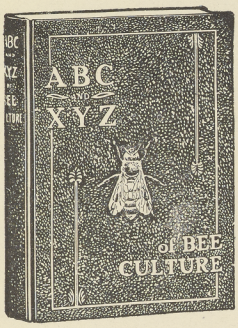

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